INTELLIGENT CONTROL OF DC MOTOR USING COMPUTATIONAL INTELLIGENCE TECHNIQUES

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Garden of Knowledge and Virtue

TAWHIDIC EPISTEMOLOGY LEADING THE WAY
UMMATIC EXCELLENCE LEADING THE WORLD
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OUR TEAM

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INTRODUCTION

DC motors are essential in many applications like automation and robotics because they require precise speed and position control. However, traditional PID controllers often struggle when dealing with nonlinearities, load changes, and disturbances. To overcome these challenges, Computational Intelligence methods such as Fuzzy Logic and ANFIS provide better adaptability and robustness. This project focuses on designing and comparing PID, Fuzzy Logic, and ANFIS controllers to achieve more accurate and reliable DC motor performance.

OBJECTIVES

1. To understand and model how a DC motor behaves.

2. .Implement PID, Fuzzy Logic, and ANFIS controllers.

3. Analyze controller performance using MATLAB on speed tracking, overshoot, settling time, steady state error and MSE.

4. To compare all controllers and find which works best for stable and accurate motor performance.

DC MOTOR MODELLING

DC MOTOR PARAMETERS

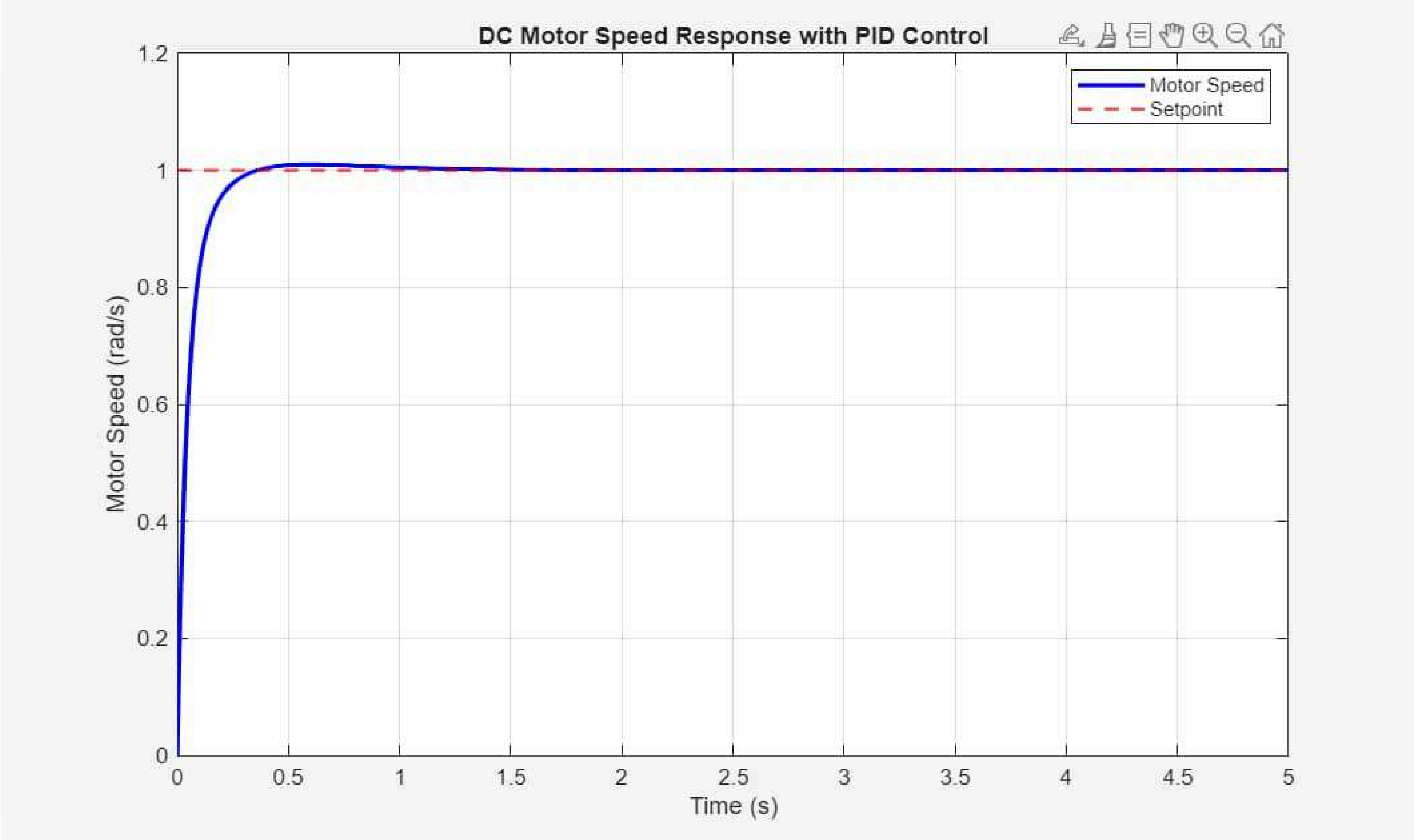
- Resistance, $R = 1$ Ohm
- Inductance, $L = 0.5$ H
- Rotor Inertia, $J = 0.01$ kg.m^2
- Viscous Damping, $B = 0.1$ N.m.s
- Motor Constant, $K = 0.01$

TRANSFER FUNCTION :

$$P(s) = \frac{K}{(Js + b)(Ls + R) + K^2}$$

CONTROLLER OVERVIEW

PID CONTROLLER



GAINS

K_p: 100

Kd : 10

K_i : 200

Input :

Error (e)

Output :

Control Signal (u)

Results :

- Setpoint: 1 rad/s
- Rise Time: 0.1311 s
- Settling Time: 0.2578 s
- Overshoot: 0.4%
- Peak Value: 1.01 rad/s at 0.5970 s
- Mean Squared Error (MSE): 0.00537
- Steady-state achieved with no undershoot

FUZZY LOGIC CONTROLLER

Sugeno Fuzzy Logic

Inputs:

- Error
- Change in Error

Output:

Control Signal (u)

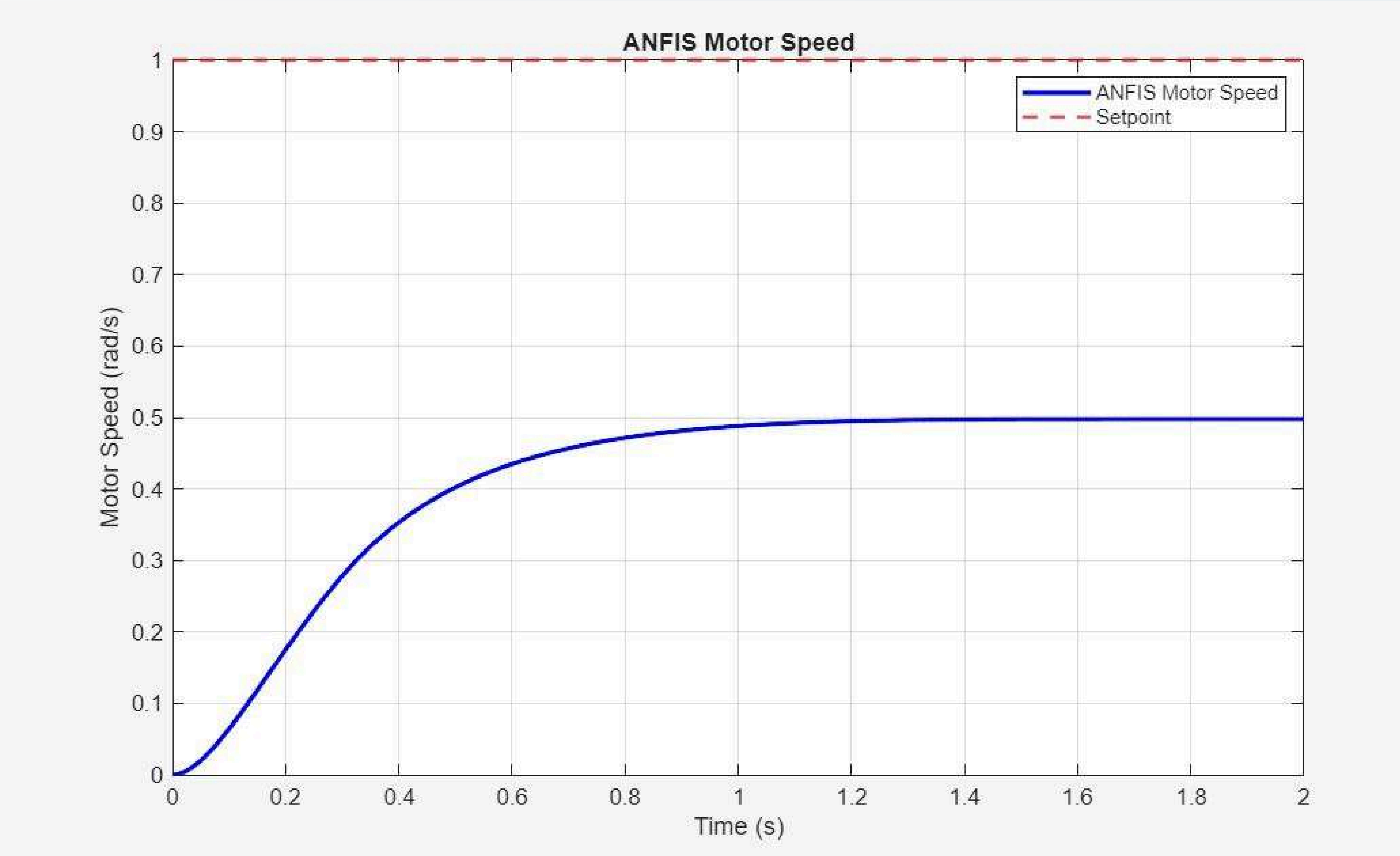
Results:

- Setpoint: 1 rad/s
- Rise Time: 0.53100s
- Overshoot: 0.00%
- Mean Squared Error (MSE): 0.20822
- Steady-state: 0.70567

ANFIS CONTROLLER

ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM

(Neural Networks + Fuzzy Logic)



Inputs :

- Error (e)
- Change of Error (de)

Output :

Control Signal (V),

calculated using a PID-like equation

Generated training data by simulating the DC motor under different setpoints and collected the corresponding errors and control actions.

- Training Data: [e, de, V] for various setpoints
- anfis to train the model

Results :

- Rise Time: 0.57000 s
- Overshoot: 0.00%
- Steady-state value: 0.49791
- Mean Squared Error (MSE): 0.35918

SIMULATION ENVIRONMENT

SIMULATION DETAILS

- MATLAB + Simulink (optional)
- Setpoint for speed: 1 rad/s
- Ran for 2–5 seconds, time step of 0.001 seconds

PERFORMANCE METRICS

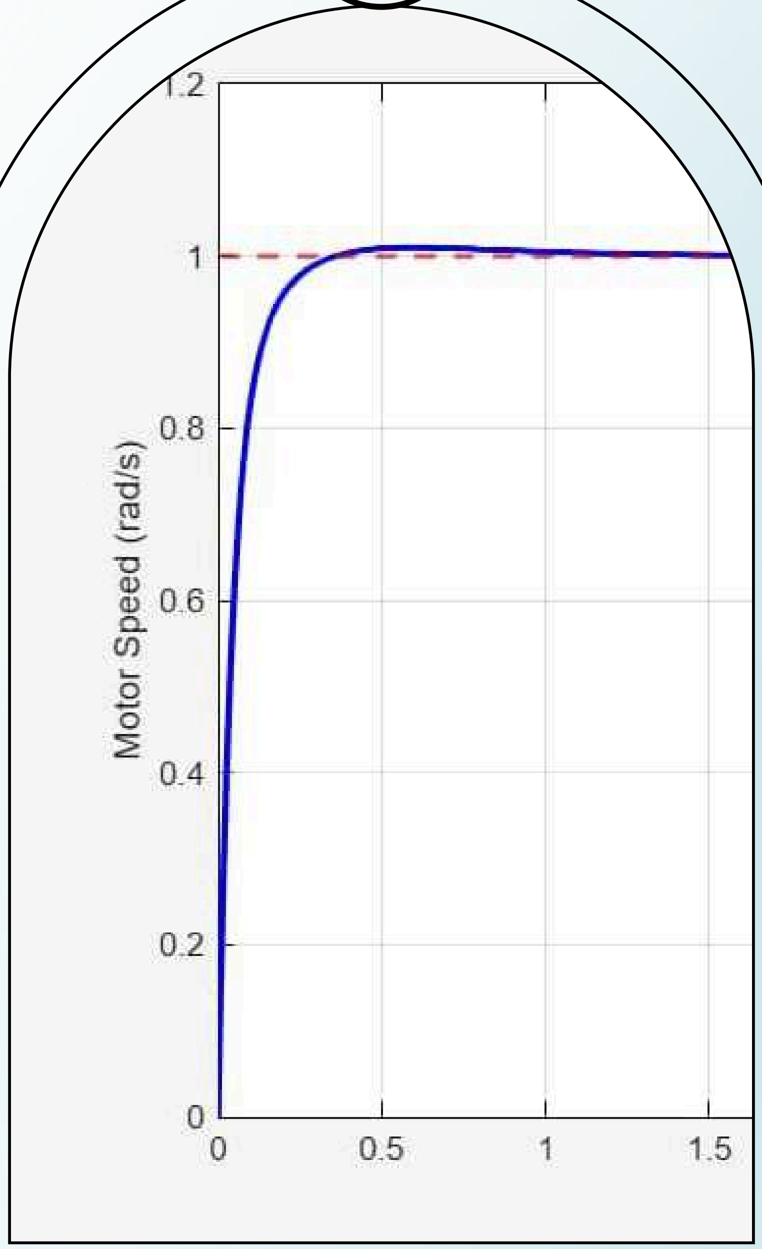
- Rise Time
- Settling Time
- Overshoot
- Peak Value
- Mean Squared Error (MSE)
- Steady-state

RESULTS COMPARISON

Metric	**PID**	**Fuzzy Logic**	**ANFIS**
Rise Time (s)	0.1311	0.531	0.57
Settling Time (s)	0.2578	–	–
Overshoot (%)	1.004	0	0
Mean Squared Error (MSE)	0.00537	0.20822	0.35918
Steady-state Value	1	0.70567	0.49791

DOCUMENTATION

01



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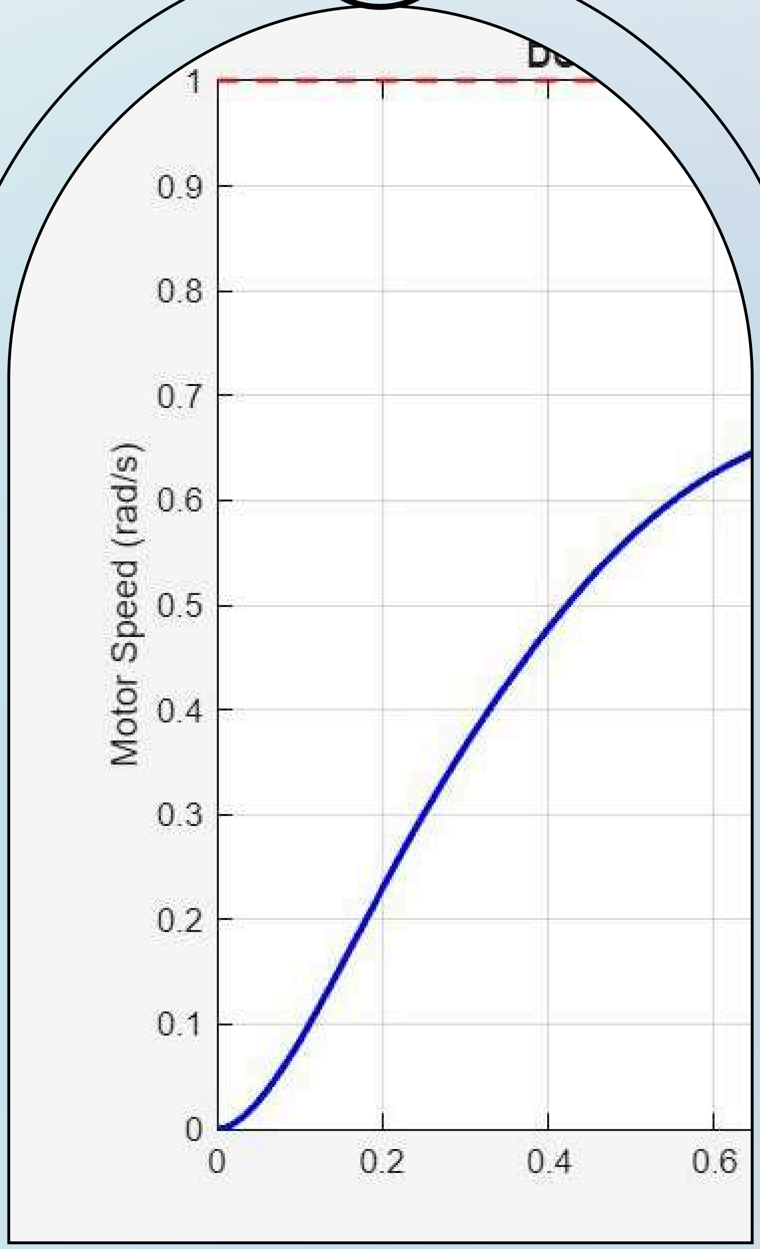

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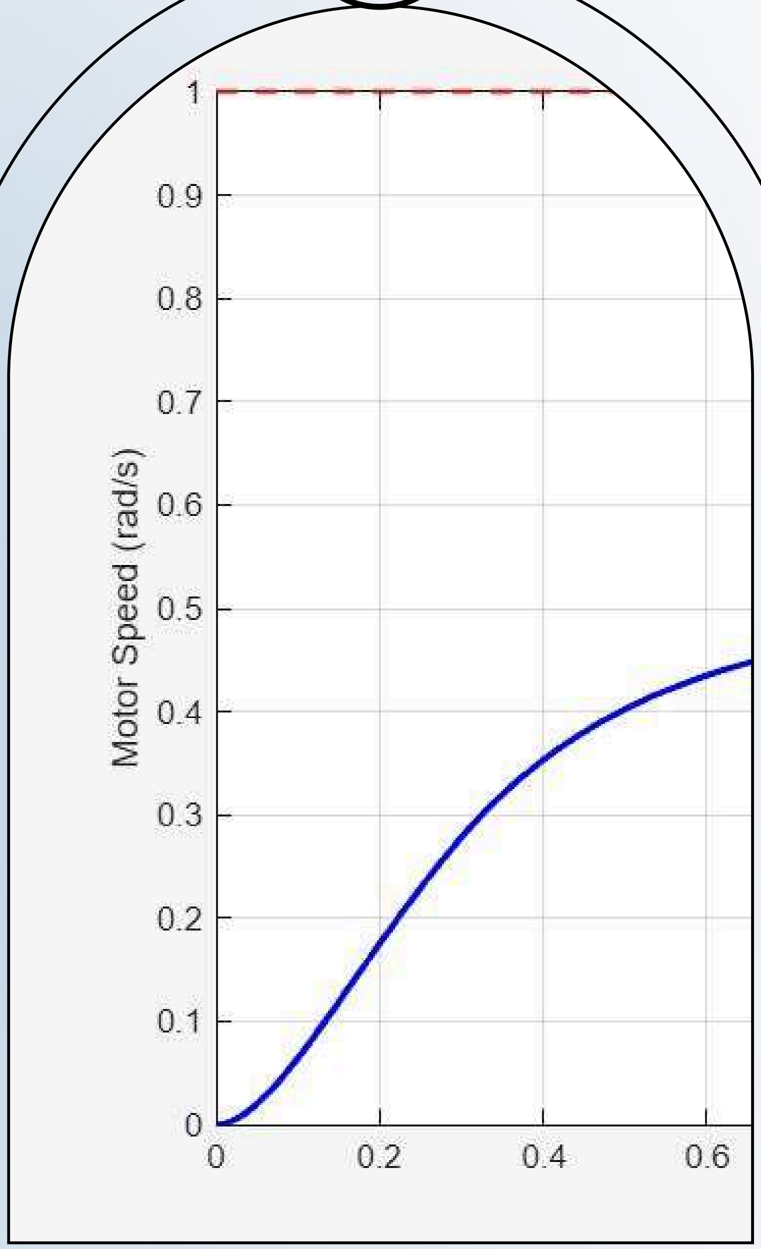

CONCLUSION

PID CONTROLLER

- ✅ Simple and widely used
- ✅ Excellent for linear systems
- ✅ Fast response and precise tracking
- ❌ Can produce overshoot
- ❌ Struggles with nonlinearities, uncertainties, or changing conditions

Fuzzy Logic CONTROLLER

- ✅ Handles nonlinearities well
- ✅ No need for precise mathematical model
- ✅ Can eliminate overshoot
- ❌ Requires careful design of fuzzy rules and membership functions
- ❌ May show steady-state errors if not tuned properly

ANFIS CONTROLLER

- ✅ Combines fuzzy logic's interpretability with neural networks' learning ability
- ✅ Learns complex nonlinear relationships from data
- ✅ Adaptive to system changes
- ❌ Needs large, high-quality training data
- ❌ Can be complex to design and train

THANK YOU